



# STS-95

## *A Summary of Findings*

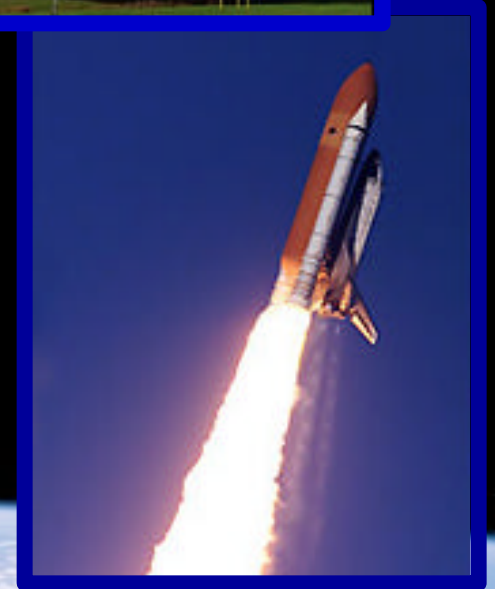
**Arnauld E. Nicogossian, M.D.**

*Associate Administrator*

*NASA Office of Life & Microgravity Sciences &  
Applications*



# October 29, 1998



**Commander:** Curtis L. Brown

**Pilot:** Steven W. Lindsey

**Mission Specialist 1:** Stephen K. Robinson

**Mission Specialist 2:** Scott E. Parazynski

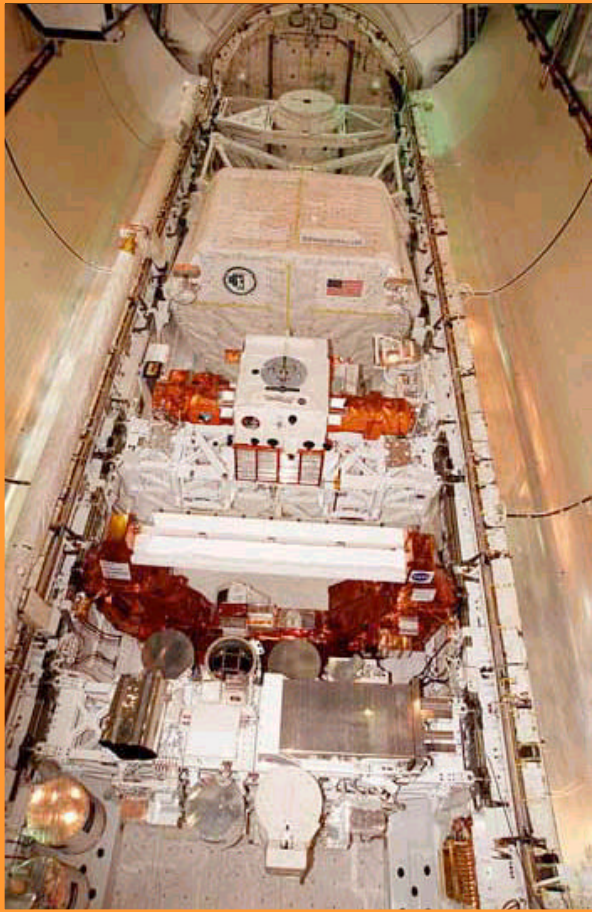
**Mission Specialist 3:** Pedro Duque

**Payload Specialist 1:** Chiaki Mukai

**Payload Specialist 2:** John H. Glenn

# STS-95 Research Agenda

*A view of the SPACEHAB module on STS-95*



## *Investigations included:*

- Life Sciences
  - Collaboration with NIH/NIA
  - Baltimore Longitudinal Study on Aging
- Astronomy
- Commercial

*SPACEHAB, Inc., initiated a buyback program, whereby payload space was sold to commercial interests for stowage in its pressurized module.*



# Breaking New Ground

- A partnership between NASA and the National Institute on Aging (NIA)
- A septuagenarian crewmember in examining physiological changes which are common to both space flight and aging
- A nine-day mission focused with > 80 experiments ranging from understanding the Sun to human adaptation to space



# STS-95 Goal

*To expand scientific understanding in the life and physical sciences, including an examination of the parallels between aging and spaceflight*



***By the year 2050, 100 million Americans will be 65 or older; 18.9 million will be 85 or more.***



## ...and Vice Versa

*Understanding the aging  
process on Earth may  
help improve the living  
and working  
environment for  
astronauts today and on  
future exploration  
missions*



# Why Senator Glenn?

*We may gain insight by  
including a person who has  
already undergone much of the  
aging process*

- Has space flight experience
- Meets the standards
- Has a lifelong, controlled database
- Represents a unique longitudinal perspective spanning varied environments



# Human Response to Space Flight

Many of the physiological adaptations that astronauts experience in flight and postflight resemble those of the aging process on Earth.

■ Adaptive  
■ Pathological

Neurosensory & Neuromotor

Cardiovascular/  
Pulmonary

Endocrine

Musculoskeletal

*Balance disorders*  
*Cardiovascular deconditioning*  
*Decreased immune function*  
*Muscle atrophy*  
*Bone loss*



Radiation

Confinement



# Muscle Fiber Response

Earth

TSH

+

IGF-1  
receptor?

=

Slow and  
Fast-twitch  
Muscle Fiber  
Development

*Proposed causal pathway*

Space

TSH

+

IGF-1  
receptor?

=

Long-chain  
Myosin  
Slow-twitch  
Muscle Fiber  
Development



# Bone Response

Bone  
Formation  
& Density

Earth

PTH  
&  
IGF-I



Osteoprogenitor  
Number &  
Bone  
Mineralization

Space

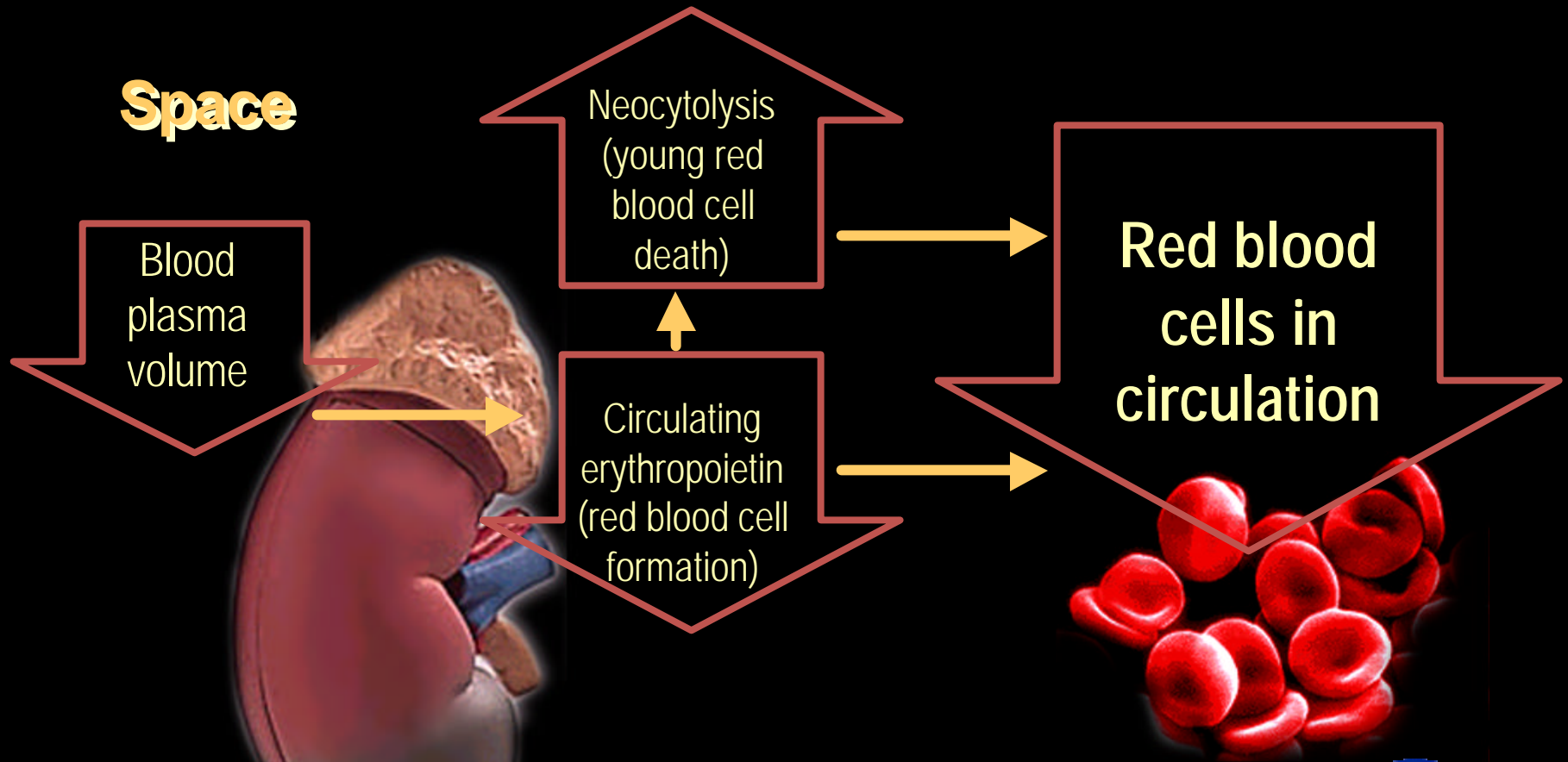
PTH  
&  
IGF-I



Osteoprogenitor  
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Mineralization

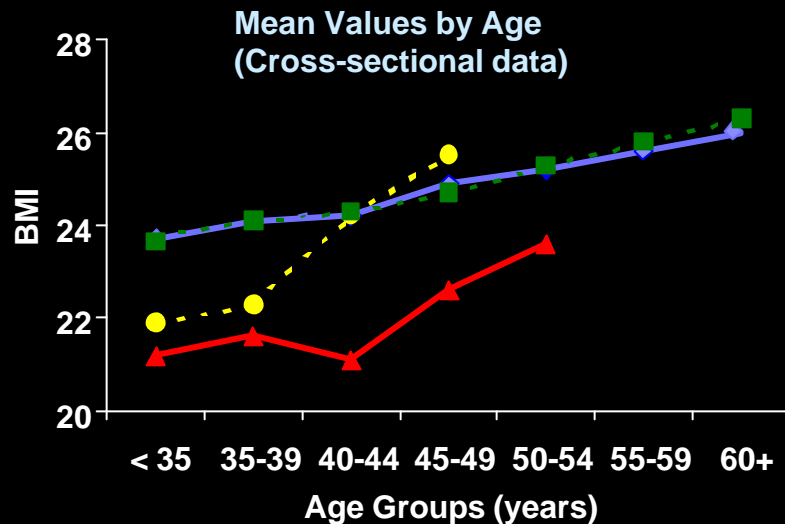


# Red Blood Cell Response

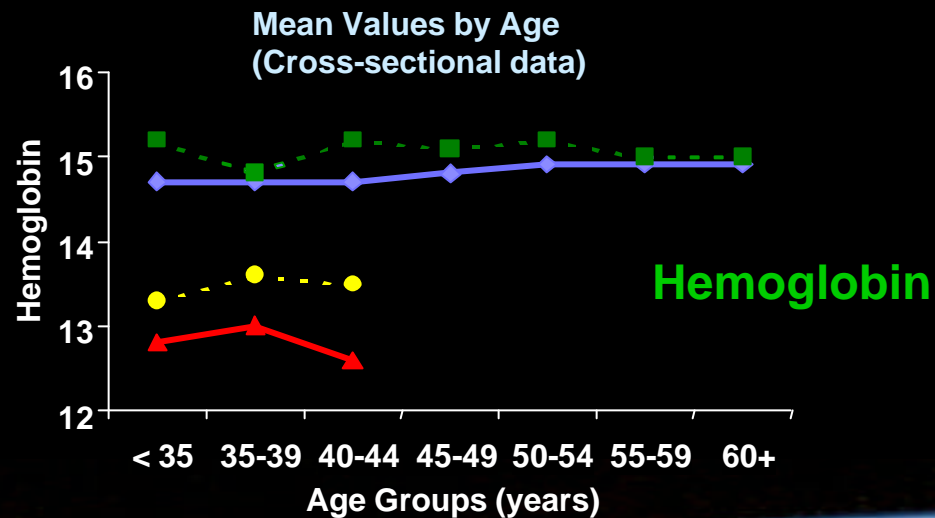
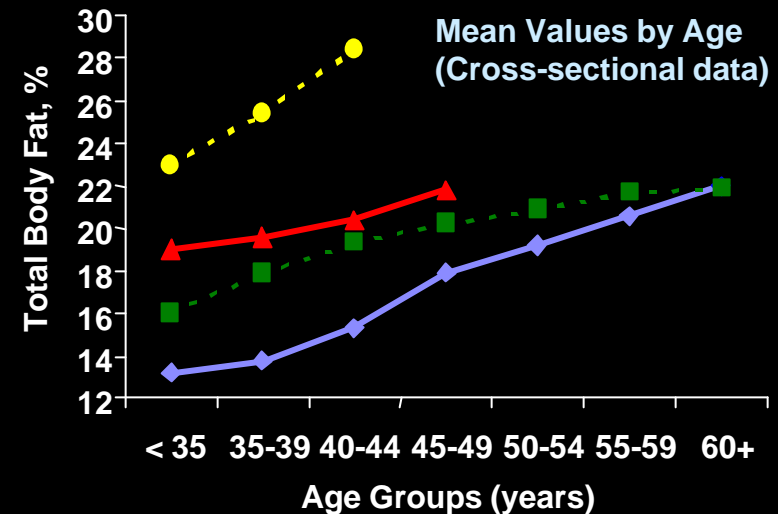


# Baseline Data from LSAH

## Body Mass Index (BMI)



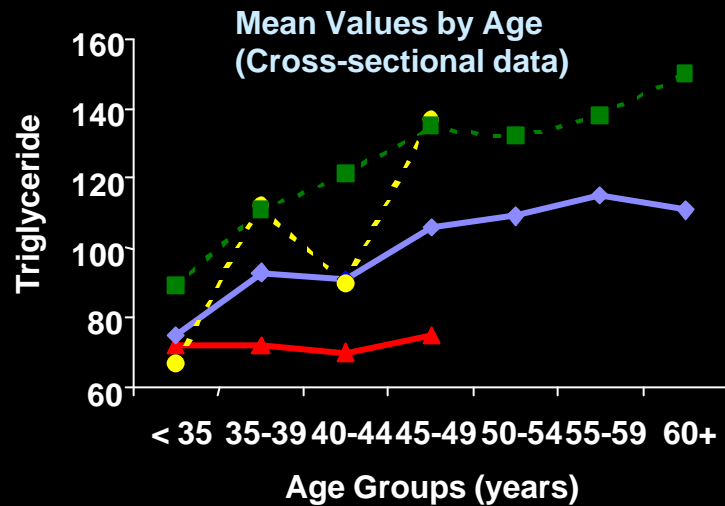
## Total Body Fat



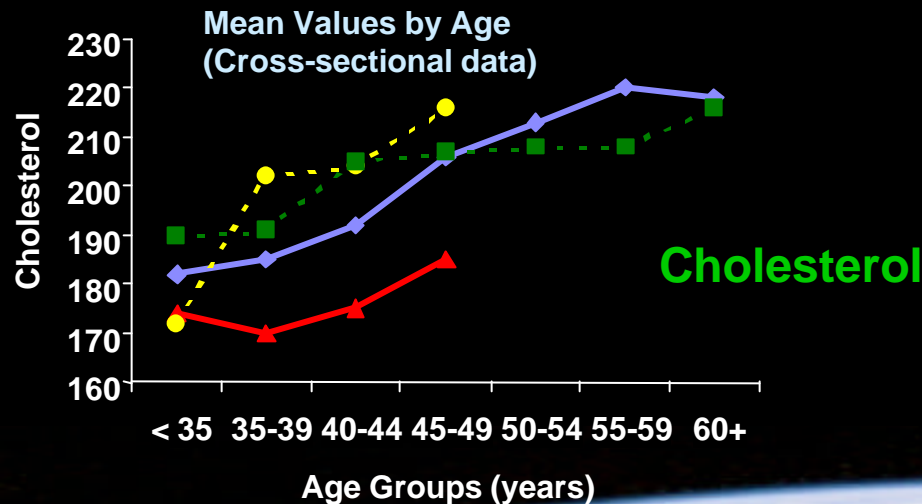
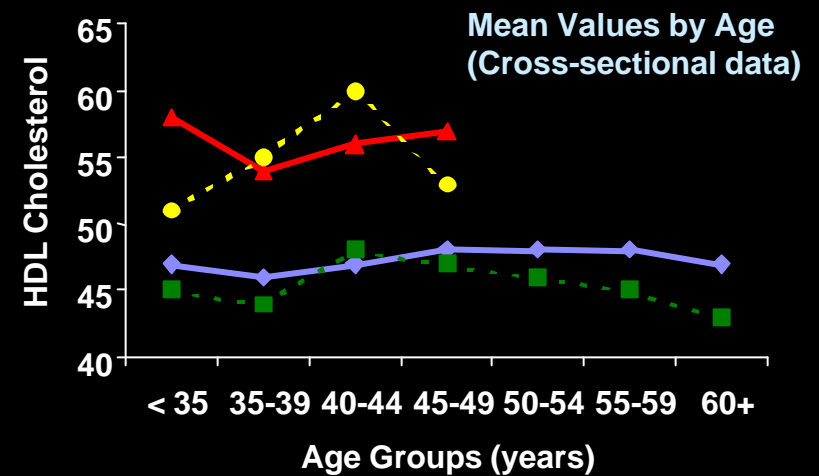
- Female Astronauts
- Female Comparisons
- Male Astronauts
- Male Comparisons



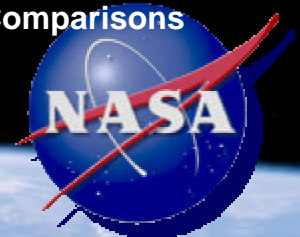
## Triglyceride



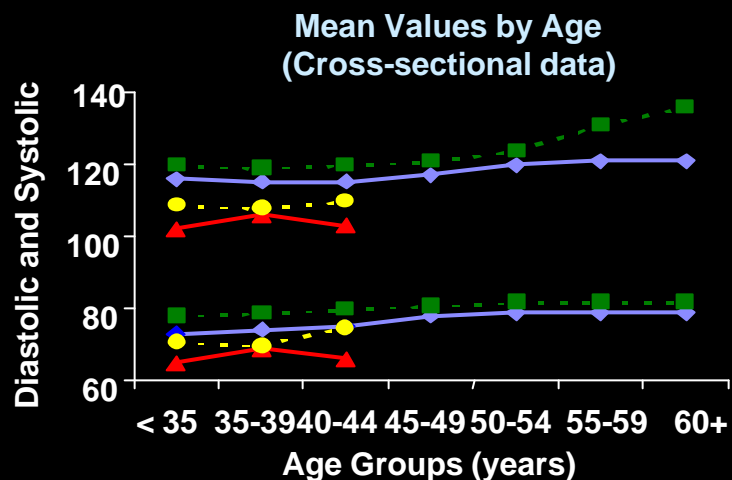
## HDL Cholesterol



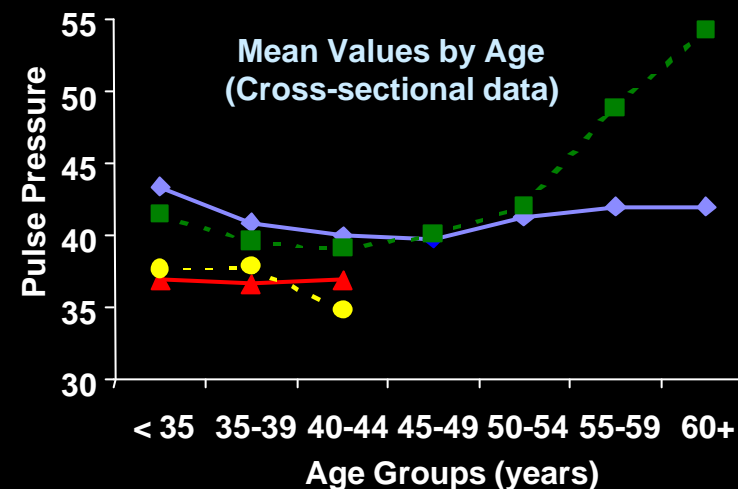
- ▲— Female Astronauts
- Female Comparisons
- ◆— Male Astronauts
- Male Comparisons



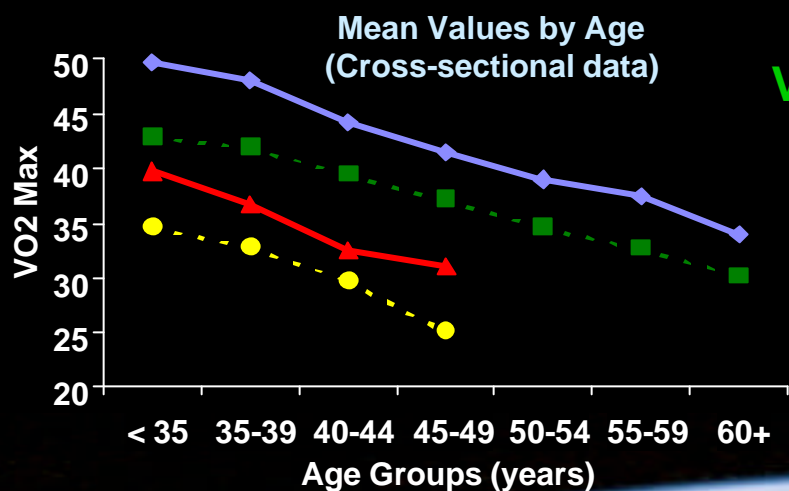
## Sitting Blood Pressure



## Pulse Pressure



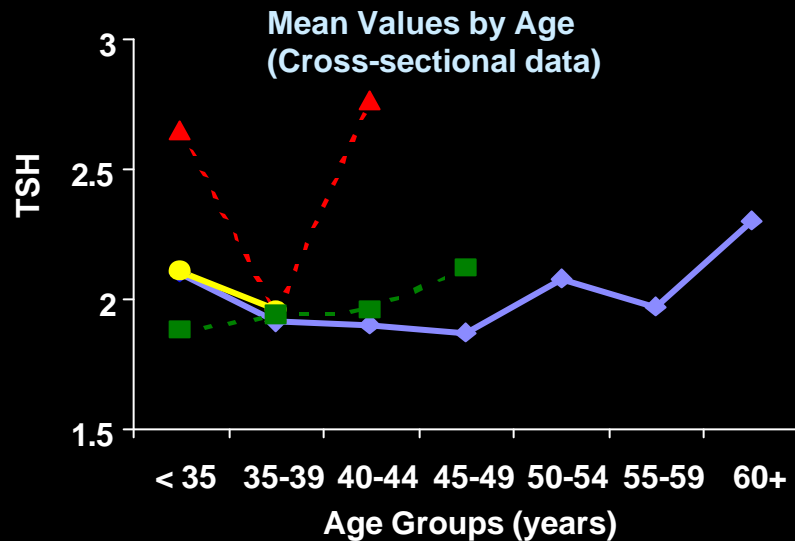
## VO<sub>2</sub> Max



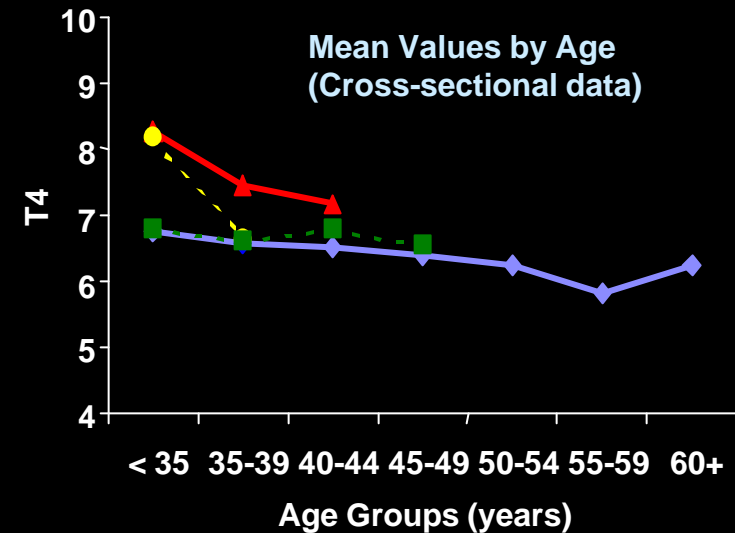
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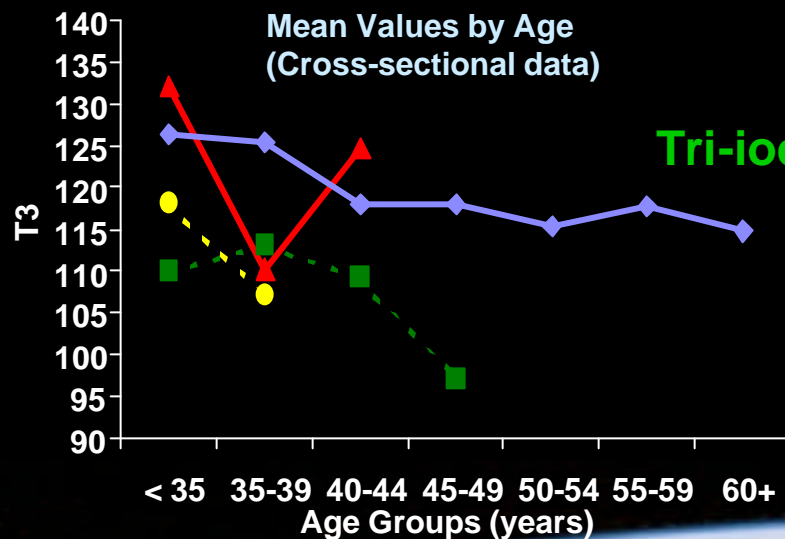
## Thyroid Stimulating Hormone (TSH)



## Thyroxine (T4)



## Tri-iodothyronine (T3)



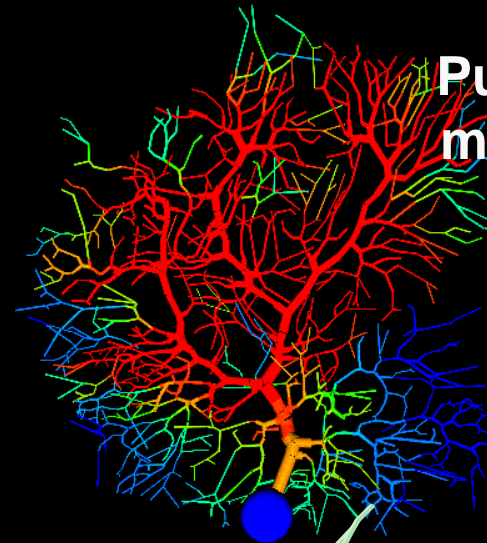
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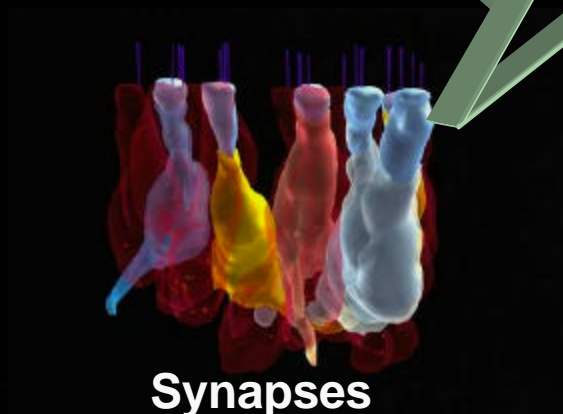
# Plasticity

Rapid changes in  
function and  
structure to high  
or low  
acceleration  
forces

Purkinje cell  
morphology



Type of  
Response



Synapses

*Ataxia*  
*SMS*  
*Occular*





John Glenn from 1964

- Astronauts experience an adaptive period in microgravity that resembles motion sickness
- Upon returning to gravity, they experience dizziness and inability to maintain their balance upon returning from space flights

## Balance Disorders



- Elderly Americans fall more often
- They suffer from gait and postural disorders

## Study Results

Senator Glenn was able to withstand the sensory motor adaptive stresses associated with space flight similar to the astronauts half his age.

His recovery rate after landing was similar to those of younger crewmembers.

# Balance Preflight Data

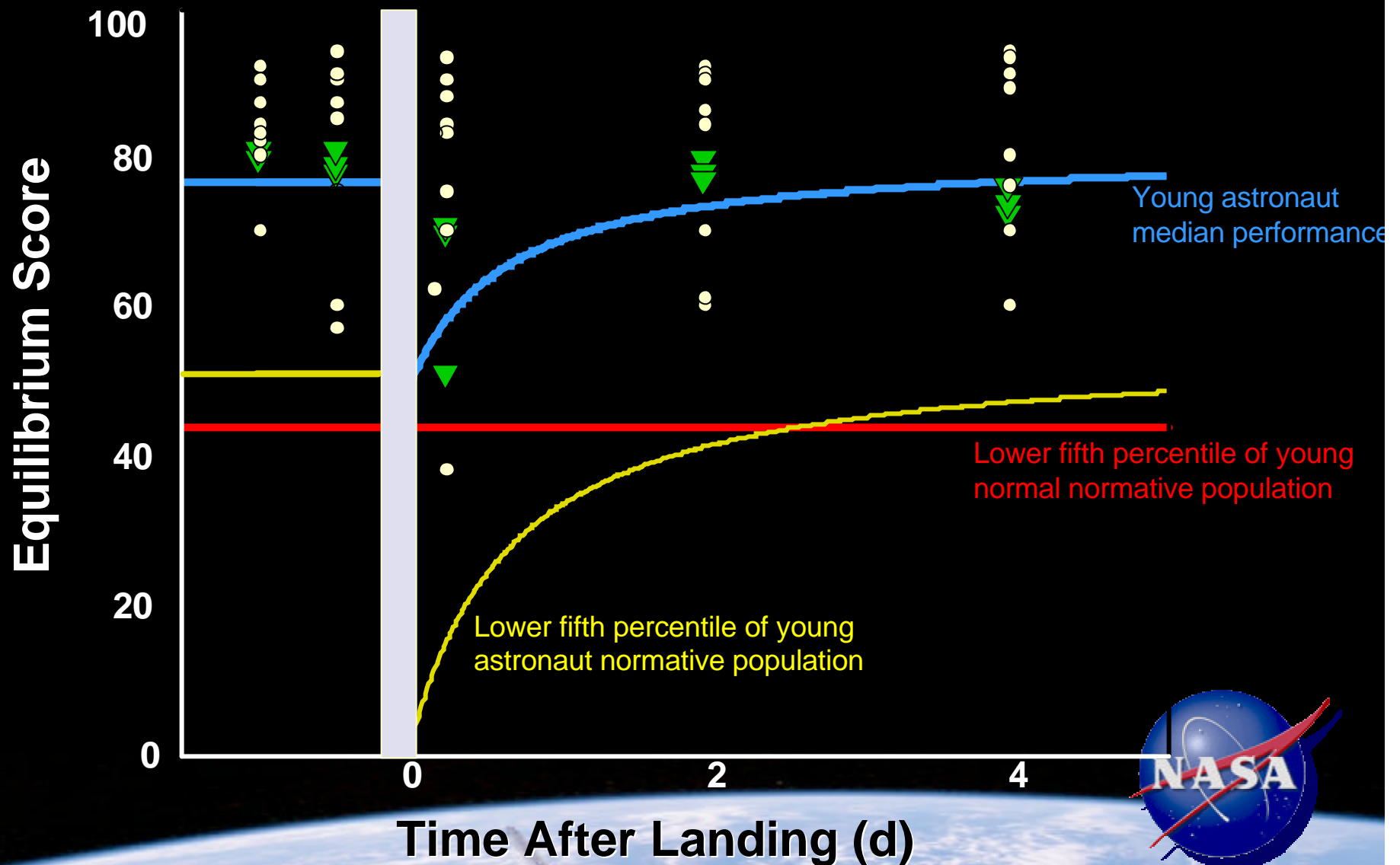
Test Condition			Normative Population		
Test	Vision	Proprioception	Young Normals (20–59 yrs)	Young Astronauts (32–50 yrs) (n=45)	Elderly Normals (75–79 yrs)
SOT 1	EO	fixed	94, 90	94, 88	92
SOT 2	EC	fixed	92, 85	89, 79	91
SOT 3	sway-ref	fixed	91, 86	92, 84	91
SOT 4	EO	sway-ref	82, 70	89, 78	77
SOT 5	EC	sway-ref	69, 52	76, 60	55
SOT 6	sway-ref	sway-ref	67, 48	75, 53	54

Test	Elderly Astronaut (77 yrs) (n=1)	Control Astronauts (37–42 yrs) (n=3)
SOT 1	91 ± 2.2	96 ± 2.2
SOT 2	87 ± 2.7	92 ± 2.4
SOT 3	91 ± 2.8	94 ± 2.2
SOT 4	85 ± 1.9	94 ± 1.6
SOT 5	75 ± 4.7	80 ± 7.4
SOT 6	79 ± 3.1	83 ± 10.9

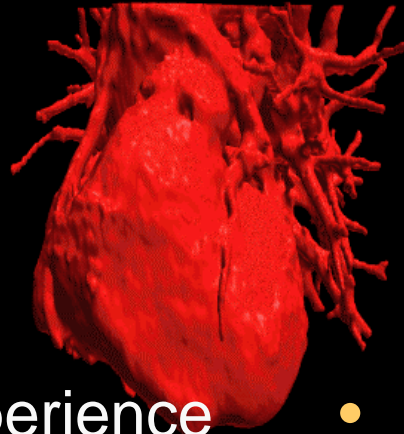


- ▼ Senator Glenn  
● 3 control crewmembers

# Postflight Data



# Cardiovascular Deconditioning



- Astronauts experience decreased cardiovascular function and heart arrhythmias
- Elderly Americans are also prone to cardiovascular deconditioning and heart rhythm changes

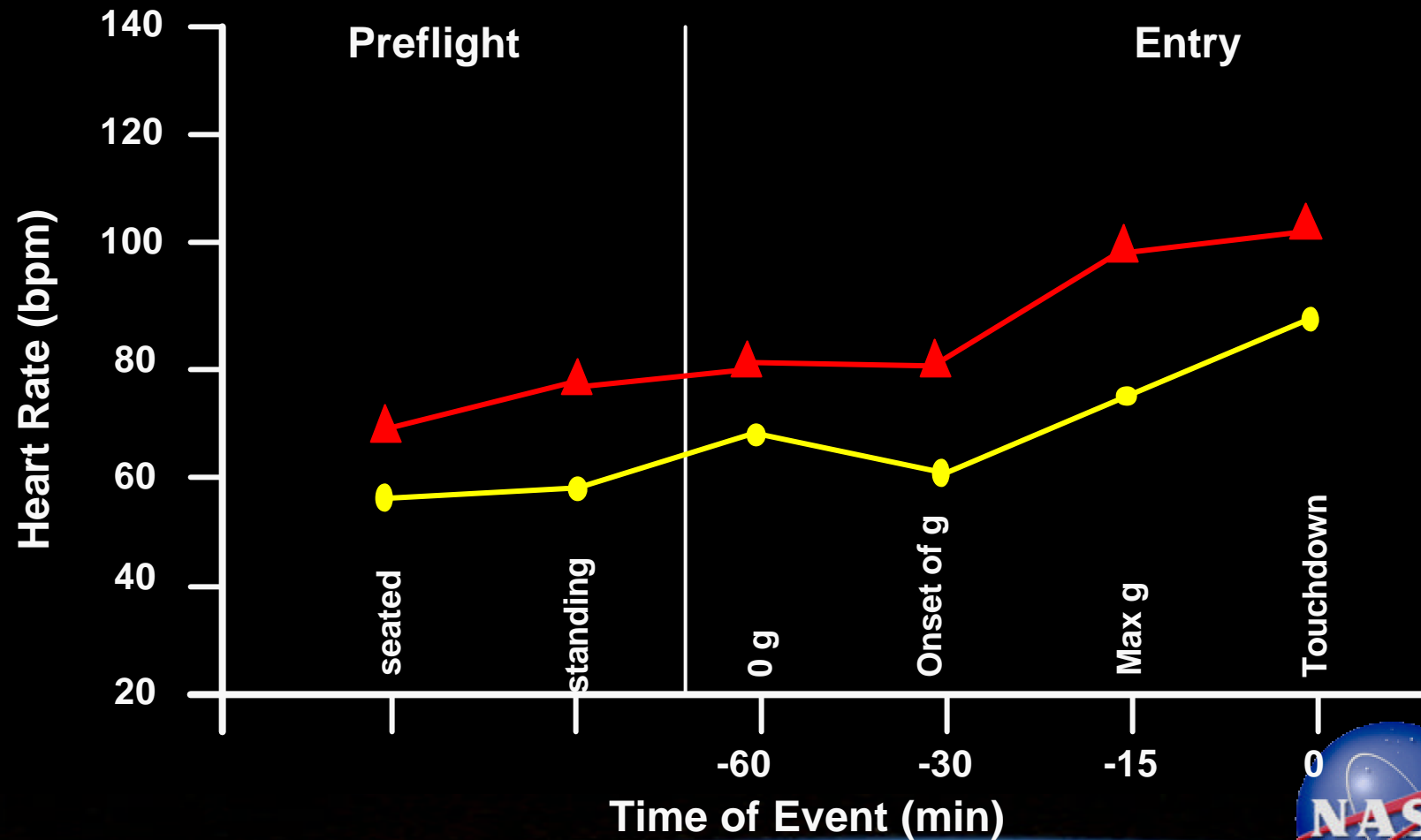
## Study Results

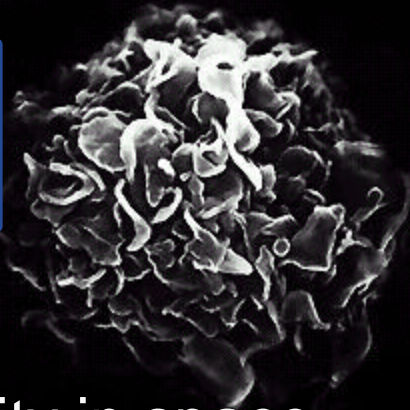
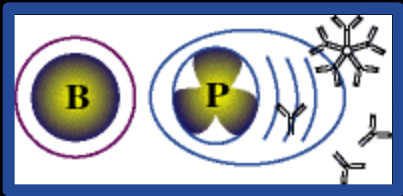
From Senator Glenn's results, there appears to be no significantly greater cardiovascular stress in an elderly person.



# Heart Rate Response During Entry and Landing

- ▲ Group N=34
- Septuagenarian N=1





# Decreased Immune Function

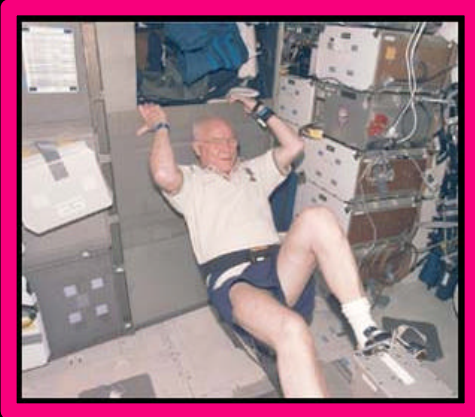
- Immunity in space travelers decreases due to combined effects of microgravity and stress.
- Models of age-related changes in immune function are difficult to find, so microgravity may be a very useful model.

## Study Results

Stress decreases immune function preflight, but the greatest decrease occurs in flight.

Senator Glenn's leukocyte levels at landing differ from young astronauts; however, as the length of flight increases, the hormonal profiles and leukocyte levels become similar.





# Muscle Atrophy

- The body's production of protein is greatly reduced during space flight
  - increased cortisol production
  - decreased testosterone production
  - caloric deficit
  - hormonal environment
- In the elderly insufficient exercise, paralysis, weakness, injury, or prolonged bedrest causes a downward spiral in an individual's health over time

## Study Results

Senator Glenn did not exhibit any significant muscle atrophy or change in muscle relaxation time in the targeted muscle groups.



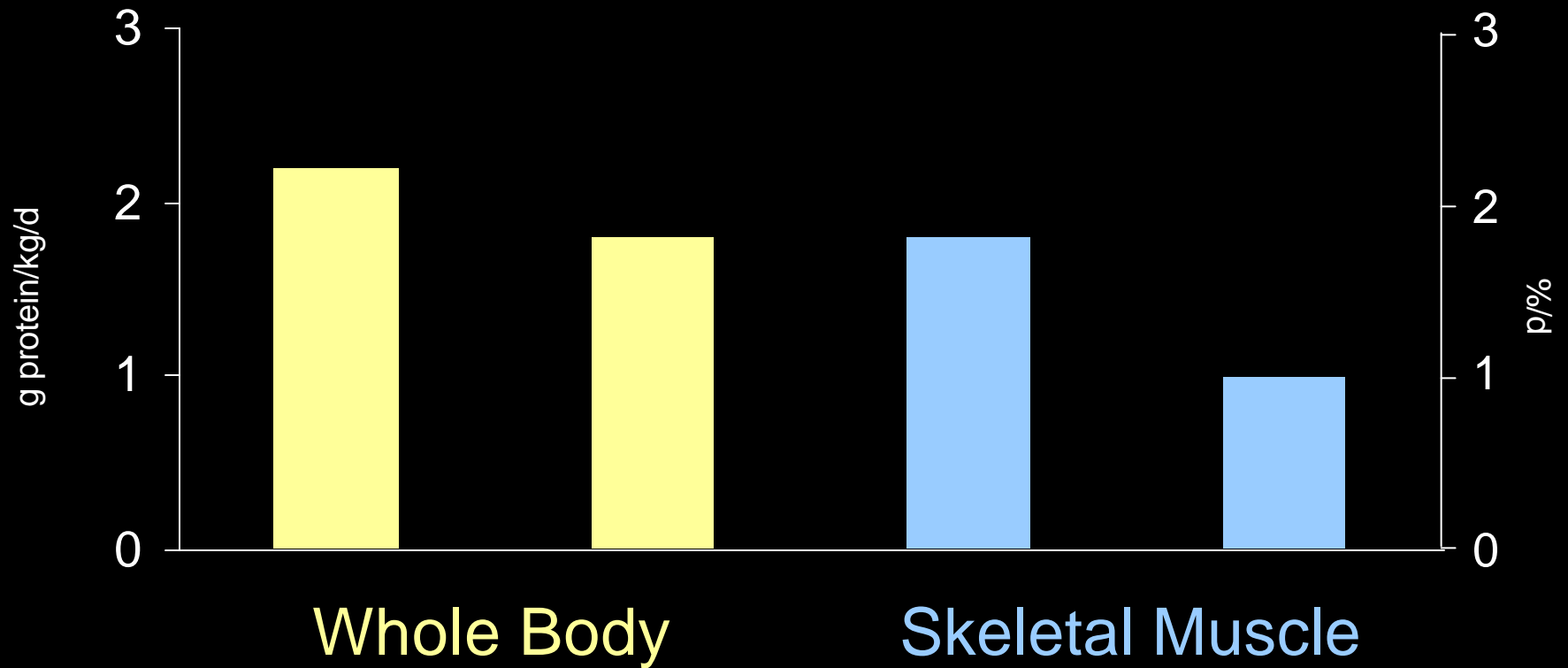
# Muscle Strength Changes with Space Flight

<u>Mission</u>	<u>Duration</u>	<u>Measure</u>	<u>%D*</u>
Salyut 7	7 days	Plantar flexion	-20
Skylab 3	59 days	Arm flexion,	-5
		leg flexion,	-20
		leg extension	-25
Mir	110-237 days	Dorsiflexion, plantar flexion	-33 -26

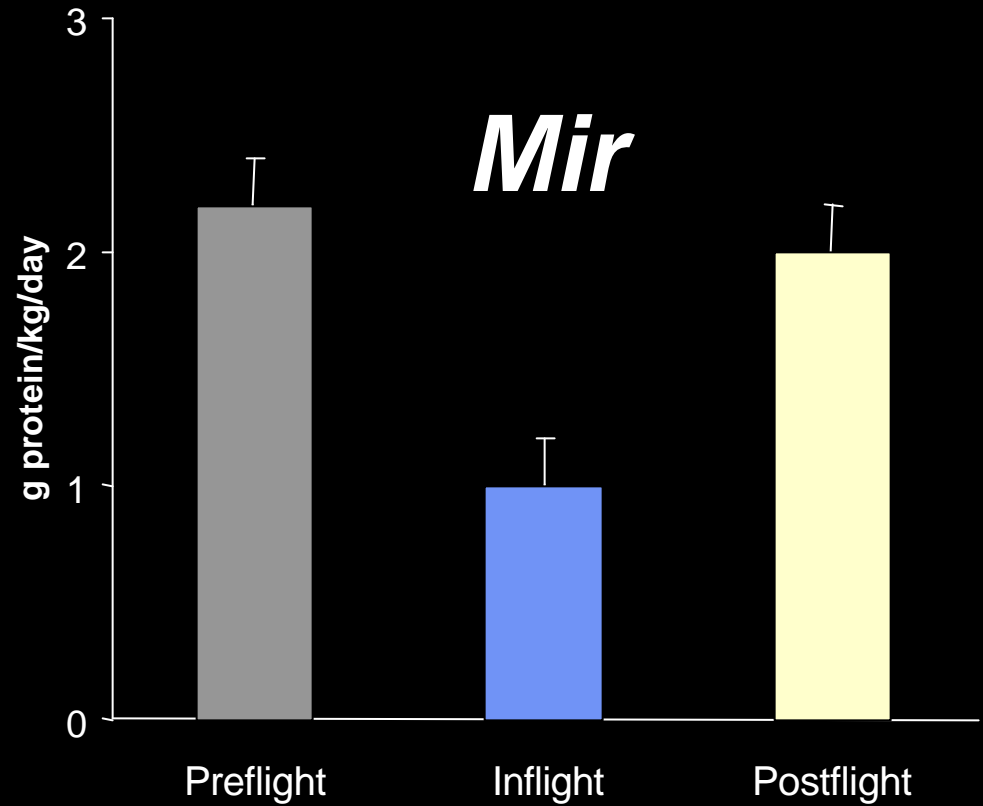
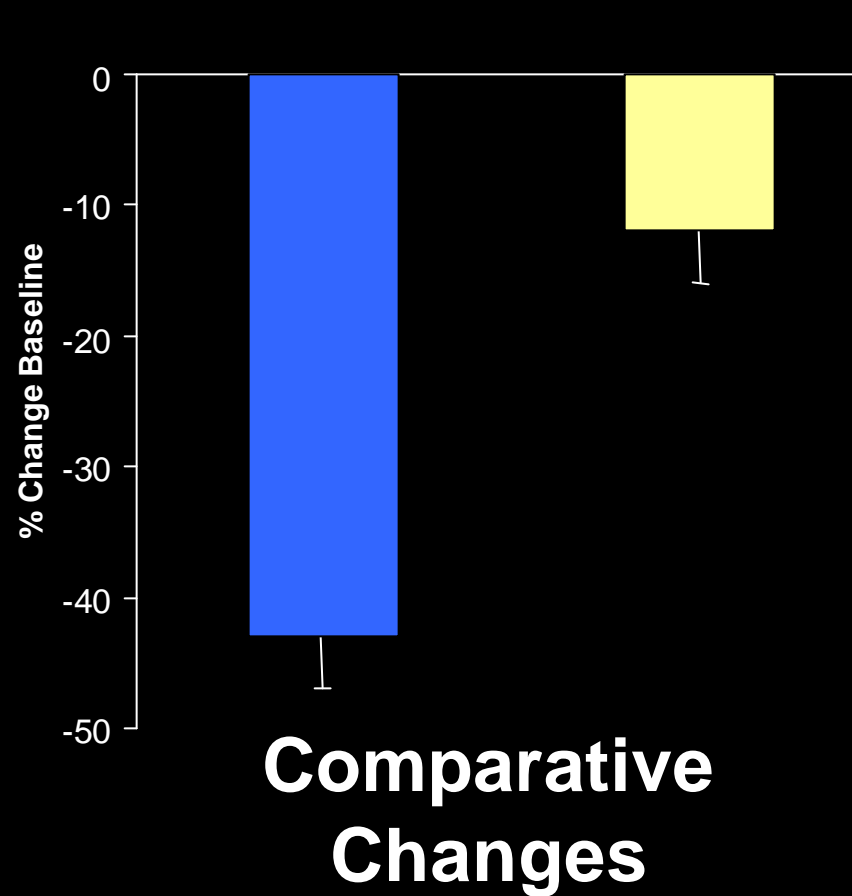
\*from baseline



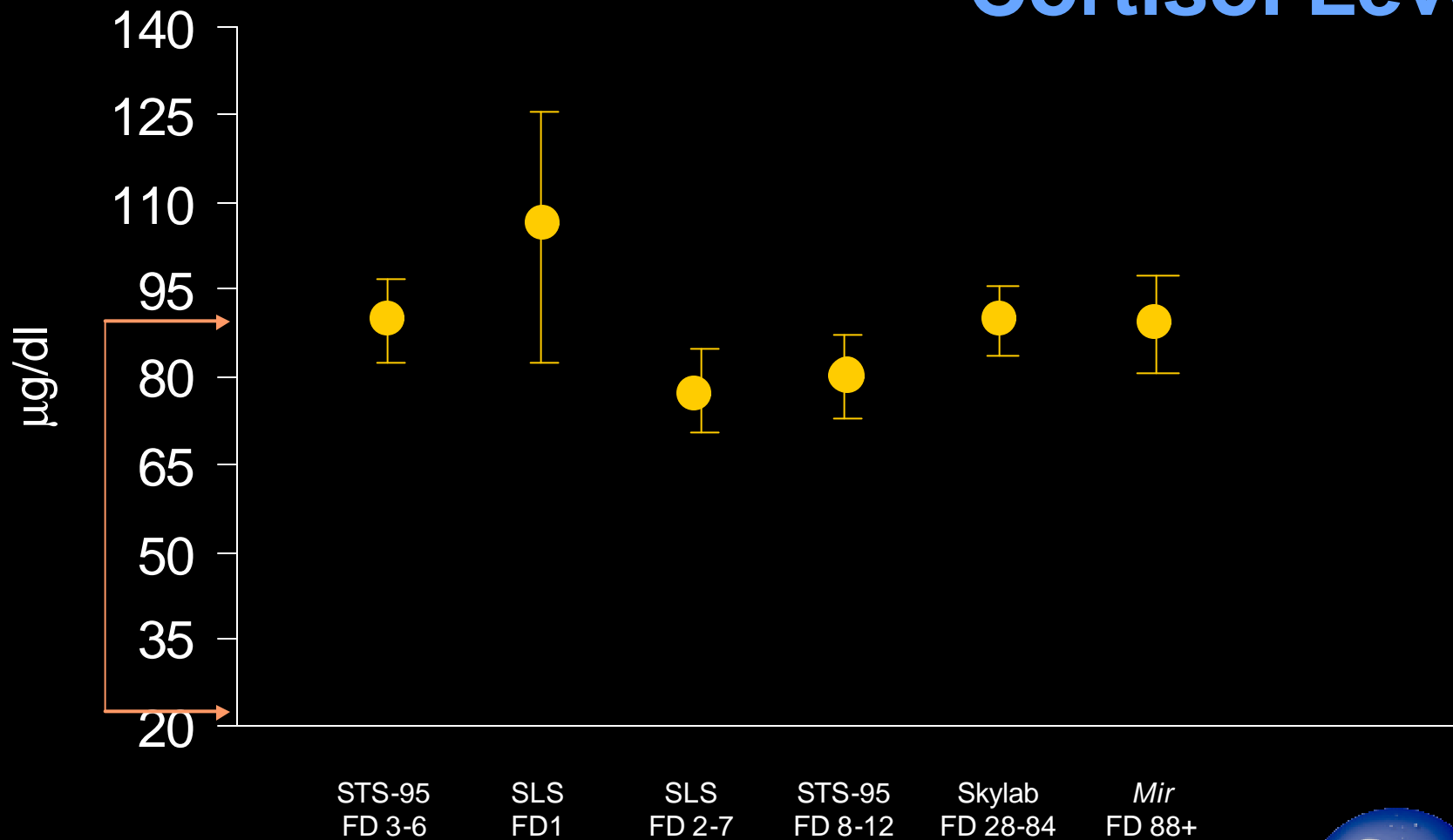
# Changes in Protein Synthesis During Bed Rest



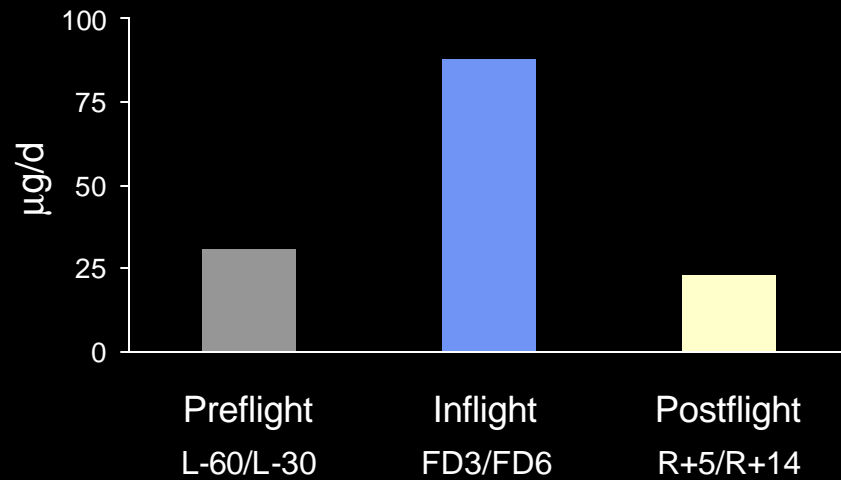
# Whole-Body Protein Synthesis



# 24-hour Urinary Cortisol Levels

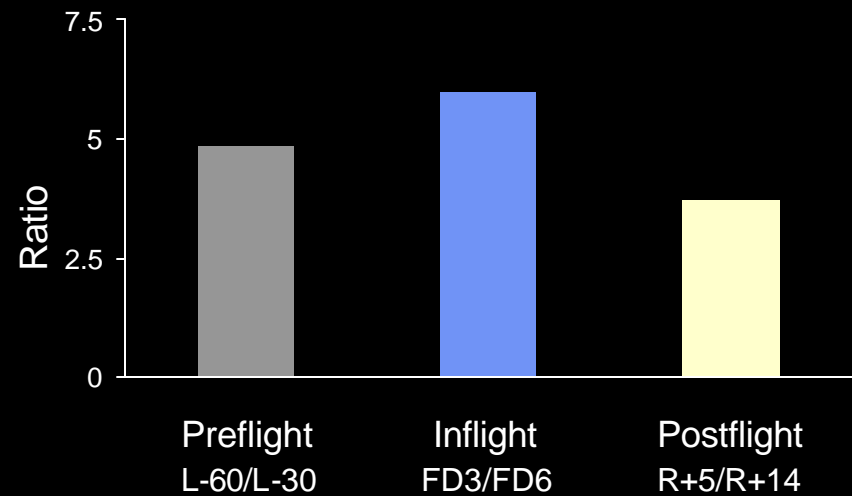


# STS-95 Cortisol Levels

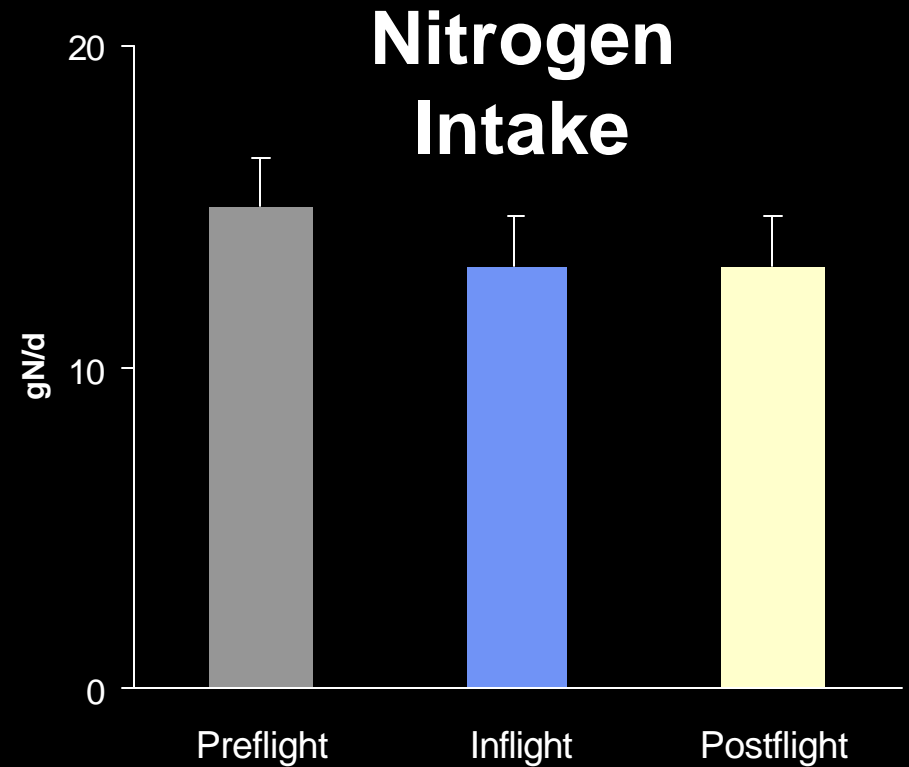
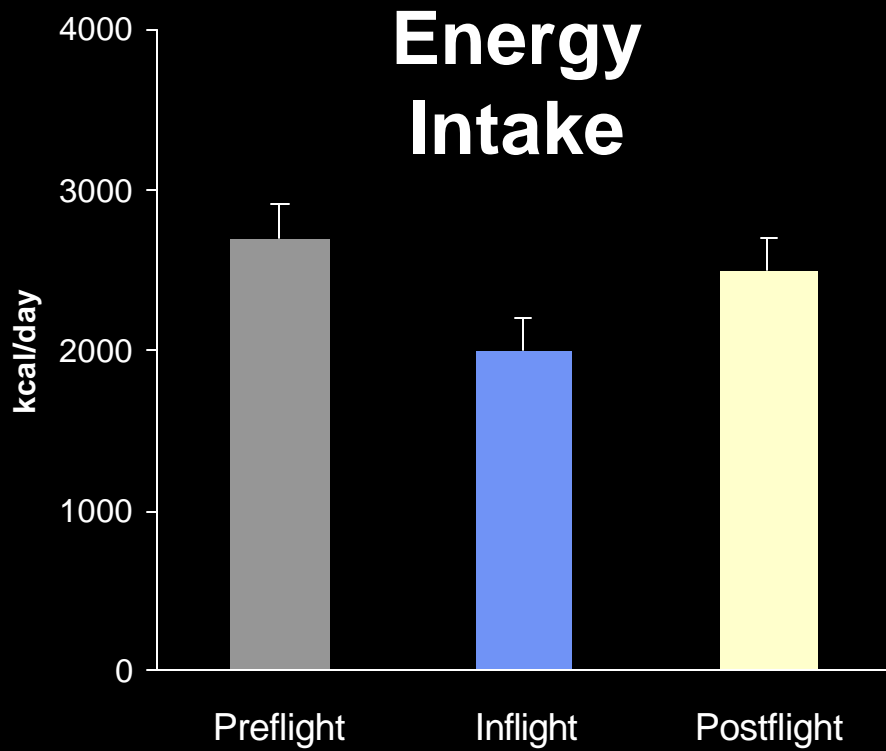


**Urinary  
Cortisol  
Excretion**

**Blood  
Cortisol/  
Testosterone**



# *Mir* Dietary Intake (>3 months in orbit)



# Bone Loss



Astronauts experience bone and mineral loss and decreases in bone density in space flight

On Earth, the elderly population experiences bone and mineral loss, leading to increased risk of fractures and injuries

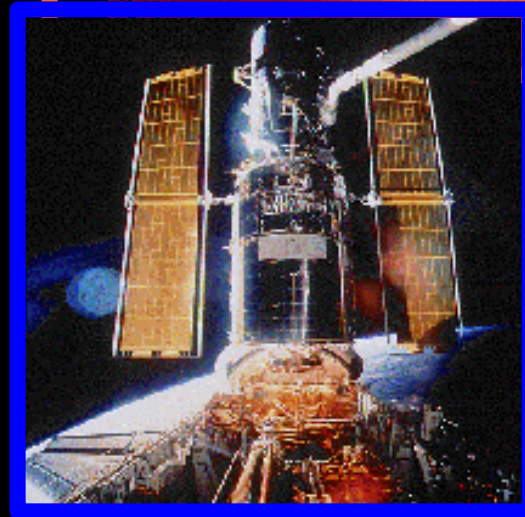
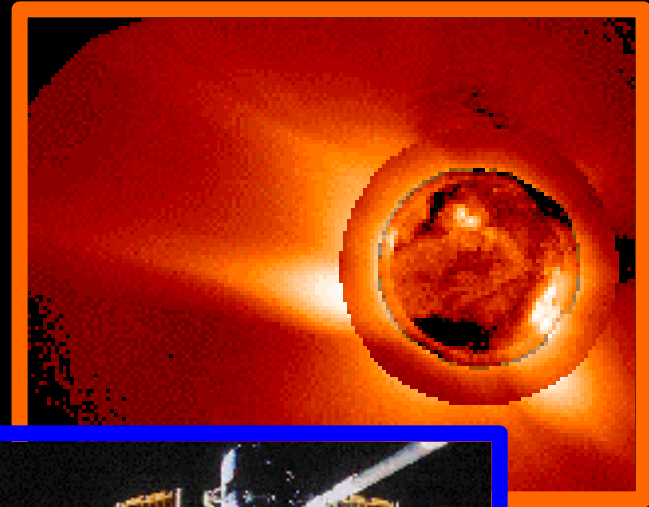
## Study Results

Senator Glenn showed no significantly greater amount of bone and mineral loss than other crewmembers. Further study using longer durations in space will need to be conducted.



# Astronomy Payload

- SPARTAN 201-5
- Hubble Space Telescope  
Orbital Systems Test  
(HOST)
- International Extreme  
Ultraviolet Hitchhiker  
(IEH-3)



# Space Product Development Program



*partnership  
between NASA,  
academia, and  
private industry*

Astroculture

Aerogel

Advanced Separations Systems

Commercial Generic  
Bioprocessing Apparatus

Commercial ITA Biomedical  
Experiment (CIBX)

Commercial Protein Crystal  
Growth (CPCG)

Vapor Diffusion Apparatus

Microencapsulation Electrostatic  
Processing System



# Conclusion

*STS-95 raises some interesting questions...*

- Is Senator Glenn a unique experimental subject? How does genetic predisposition vs. conditioning play a role?
- Can we use surrogates in space flight for further aging research?
- Are there more similarities between space flight and aging?
- By what means do we measure aging in space flight and on Earth?

